lines, their designations, assumed wave-lengths, and relative intensities being as follows:—

Hζ, 3889, (1); Hε, 3970, (3); Hδ, 4102, (8); Hγ, 4341, (10); —, 4643, (11); and Hβ, 4862, (9).

No dark lines are shown on the photograph, but this may possibly be due to the small dispersion employed. The same lines, together with the nebula line at λ 5003, are shown on spectrograms obtained on March 29 and 31, and April 1, the nebula line appearing as brighter than Hζ and of intensity 2–3. Later photographs contain lines at the estimated positions λ 4176, λ 4240 and λ 4462.

Prof. Pickering remarks on the utility of such a series of systematic observations as are carried on under the Draper memorial fund, and states that even in the absence of Prof. Turner's discovery and prompt announcement, Nova Geminorum would have been discovered, for its spectrum was a very conspicuous object on the Harvard photograph of March 25 (H.C.O. *Circular*, No. 70).

RECENTLY DISCOVERED TERRESTRIAL GASES IN THE CHROMOSPHERE.—Owing to their proved relationship to helium, Prof. S. A. Mitchell, of Columbia University, suspected that the recently discovered gases neon, argon, krypton, and xenon might be found to exist in the chromosphere, and in order to test his supposition he compared the wave-lengths of the lines in their respective spectra with the wave-lengths of the chromospheric spectrum obtained by himself during the Sumatra eclipse.

Owing to the low densities of the new gases, it is to be expected that, as is the case with helium, they will not appear in the normal solar spectrum, even though they may appear in the spectrum of the chromosphere; and again, owing to the low atomic weights of neon and argon, Prof. Mitchell expected that these two gases might appear in the spectrum, whilst krypton and xenon, the atomic weights of which are greater, would probably not so appear.

As a result of his comparison Prof. Mitchell comes to the conclusion that lines due to neon and argon are present in the chromospheric spectrum, but the evidence as to the presence of krypton and xenon is, at present, inconclusive. Lines which are due to the more volatile gases of the earth's atmosphere (*i.e* those which are uncondensed at the temperature of liquid hydrogen), as published by Liveing and Dewar, appear at λλ 4047, 4398, 4422, 4431, 4540 and 4844, and the strongest argon lines, viz. those at λλ 4180·3, 4200·8, 4259·5, 4266·8 and 4430·3, are also represented in the spectrum of the chromosphere.

Prof. Mitchell suggests that these gases may have come to the earth's atmosphere from the sun, as suggested in the theory put forward by Arrhenius, which supposes that ionised particles are constantly being repulsed by the pressure of light, and thus journey from one sun to another (*Astrophysical Journal*, No. 3, vol. xvii.).

CATALOGUE OF MEASURES OF NEW DOUBLE STARS.—In *Bulletin* No. 29 of the Lick Observatory, Prof. R. G. Aitken publishes a further addition of 117 new double stars and their measures to his new catalogue of these objects; the earlier sections of this catalogue have already appeared in previous numbers of the Lick *Bulletins* and in the *Astronomische Nachrichten*.

The present section deals with Nos. 313 to 429 (Aitken) inclusive, and gives the position for 1900, the number in previous catalogues, the magnitude and the dates and figures of the various measures for each star. More than one-half of the pairs in this section are separated by angular distances not exceeding 1″, and more than three-fourths are only separated by 2″ or less.

The doubles have been discovered with the 12-inch telescope, but nearly all the measures have been made with the 36-inch.

"THE CAMBRIAN NATURAL OBSERVER."—The latest issue of this interesting little volume, which is the official organ of the Astronomical Society of Wales, contains many interesting records of observations, both astronomical and meteorological, made by members of the Society during 1902. In future the "Observer" will only appear annually instead of quarterly as hitherto.

SEISMOLOGICAL NOTES.

THE last publication of the Earthquake Investigation Committee of Japan contains five papers illustrated by twenty-six plates, all of which are the work of Dr. F. Ōmori. The first of these refers to a horizontal pendulum tromometer, which is essentially a conical pendulum seismograph carrying a load of 50 kg. and writing indices with a multiplication of 120. In addition to recording earthquakes, it indicates the almost continual existence of "micro tremors," the periods of which are about 0·3 second and the range 0·013 mm. When "pulsatory oscillations," which are a larger form of disturbance than the tremors, are in evidence, it would appear from the illustrations which are given of these movements that they might seriously interfere with the character of an earthquake record.

In a communication on the overturning and sliding of columns, the relationship between the horizontal component of earthquake motion and the displacement of bodies which are not attached to the ground, but simply rest upon the same, is discussed and illustrated with considerable detail. The effects of vertical motion are referred to, and cases are pointed out where gate-posts and buildings have been caused to jump. A paper bearing upon the seismic stability of tall chimneys gives the results of experiments upon the vibration of such structures. The remaining papers respectively refer to the vibration of the piers of railway bridges as caused by traffic, and the vibration of walls at the time of earthquakes.

These excellent publications are undoubtedly of great value, especially to those who have to construct to resist earthquake movements; but if the author could have given more complete references to investigations made by himself and also by others in connection with similar inquiries, their value would have been enhanced.

Other seismological notes are found in the reports of the Physico-Mathematical Society of Tokyo. In one of these, No. 16, Dr. Ōmori gives a summary of analyses he has made of seismograms of distant earthquakes. This is followed by notes relating to the transit velocity of the first preliminary tremor of earthquakes of near origin. We are told that the duration of these early movements has a constant relationship to the distance they have travelled. Therefore, if this distance is known, and the time of arrival of the large waves has been noted, it is an easy matter to determine the time at which the preliminary tremors must have arrived. With this factor and with a knowledge of the time at which they originated, their velocity may be calculated. A mean for this is given at 5 or 6 km. per second, whilst a mean value determined from observations is 8 km. per second. In arriving at these results, it must not be overlooked that in certain cases, at least, there has been an unavoidable want of precision in locating origins; the time of occurrence at an origin has been taken as the mean of times observed at stations regarded as being near to the same, and it has been assumed that the waves followed spherical paths. These and other factors have no doubt contributed to the wide limits assigned to the results of these investigations.

In the tenth number of the new series of publications issued by the Earthquake Commission of the Vienna Academy of Sciences, Dr. E. v. Mojsisovics gives a chronological series of notes relating to 157 earthquakes which in 1901 were recorded in various parts of the Austrian Empire. The first of these catalogues, which consists of observations made for the most part without the aid of instrumental appliances, was issued in 1898.

In addition to these lists of local disturbances, which may be compared to the slight shocks which from time to time are felt in this country, the Academy also publishes registers of disturbances which have originated at great distances and shaken the world throughout its mass. Illustrations of these latter are found in the eleventh and twelfth numbers of the publications, the former referring to Trieste and the latter to Kremsmünster.

At the first of these stations, three Rebeur-Ehlert pendulums have been kept at periods of about eight seconds, whilst at the second, similar instruments have periods of from three to four seconds. In 1901, at Trieste, 187 earthquakes were recorded, whilst at Kremsmünster only eighty-one were noted. Although the natural period of the pendulums has

been comparatively short, both stations have suffered from "mikroseismische Unruhe" (air tremors?).

At the present moment the most interesting station where world shaking earthquakes are recorded is at Pribram, where on the surface and at a depth of 1100 m. Wiechert's pendulums are installed. From the few records hitherto obtained, it appears that the motion on the surface and that underground have a striking similarity.

DR. GOELDI ON BRAZILIAN DEER.

DR. E. GOELDI has decidedly advanced our knowledge of the deer of South America by a memoir on the antlers of three Brazilian species recently published in the *Memorias* of the museum at Para of which he has charge (*Mem. Mus. Goeldi*, part iii., 1902). All South American deer, it need scarcely be said, differ markedly from the more typical deer of the Old World, the males of the larger species, together with their relatives, the white-tailed and the mule deer of North America, being specially distinguished by the form of their antlers, which branch in a fork-like manner some distance above their base, instead of giving off a brow-tine close to the latter. Hitherto naturalists, in Europe at any rate, have had no definite information with regard to the gradual increase in the complexity of the antlers of the South American species as they are annually renewed. This deficiency in our knowledge has been supplied in the case of the marsh-deer, the pampas-deer, and the one commonly called *Cariacus gymnotis*, in the memoir before us. With great pains, Dr. Goeldi has collected a large series of the antlers of each of the three species belonging to animals of different ages, and in the plates accompanying his memoir has figured a selection which serves to display the gradual evolution from the young to the adult form. In the course of the memoir, it is incidentally mentioned that the aforesaid *C. gymnotis*, which is a near relative of the North American whitetail, has only recently made its appearance in Brazil, its proper home being Colombia and Guiana.

THE PEARL FISHERIES OF CEYLON.[1]

THE celebrated pearl "oysters" of Ceylon are found mainly in certain parts of the wide shallow plateau which occupies the upper end of the Gulf of Manaar, off the north-west coast of the island and south of Adam's Bridge.

The animal (*Margaritifera vulgaris*, Schum. = *Avicula fucata*, Gould) is not a true oyster, but belongs to the family Aviculidæ, and is therefore more nearly related to the mussels (Mytilus) than to the oysters (Ostræa) of our seas.

The fisheries are of very great antiquity. They are referred to by various classical authors, and Pliny speaks of the pearls from Taprobane (Ceylon) as "by far the best in the world." Cleopatra is said to have obtained pearls from Aripu, a small village on the Gulf of Manaar, which is still the centre of the pearl industry. Coming to more recent times, but still some centuries back, we have records of fisheries under the Singhalese kings of Kandy, and subsequently under the successive European rulers—the Portuguese being in possession from about 1505 to about 1655, the Dutch from that time to about 1795, and the English from the end of the eighteenth century onwards. A notable feature of these fisheries under all administrations has been their uncertainty.

The Dutch records show that there were no fisheries between 1732 and 1746, and again between 1768 and 1796. During our own time the supply failed in 1820 to 1828, in 1837 to 1854, in 1864 and several succeeding years, and finally after five successful fisheries in 1887, 1888, 1889, 1890 and 1891 there has been no return for the last decade. Many reasons, some fanciful, others with more or less basis of truth, have been given from time to time for these recurring failures of the fishery; and several investigations, such as that of Dr. Kelaart (who unfortunately died before his work was completed) in 1857 to 1859, and that of Mr. Holdsworth in 1865 to 1869, have been undertaken without much practical result so far.

[1] Abstract of a discourse delivered at the Royal Institution on March 27 by Prof. W. A. Herdman, F.R.S.

In September, 1901, I was asked to examine the records and report on the matter, and in the following spring was invited by the Government to go to Ceylon with a scientific assistant, and undertake what investigation into the condition of the banks might be considered necessary. Arriving at Colombo in January, 1902, as soon as a steamer could be obtained we proceeded to the pearl banks. In April it was necessary to return to my university duties in Liverpool, but I was fortunate in having taken out with me as my assistant Mr. James Hornell, who was to remain in Ceylon for at least a year longer, in order to carry out the observations and experiments we had arranged, and complete our work. This programme has been carried out, and Mr. Hornell has kept me supplied with weekly reports and with specimens requiring detailed examination.

The s.s. *Lady Havelock* was placed by the Ceylon Government at my disposal for the work of examining into the biological conditions surrounding the pearl oyster banks; and this enabled us on two successive cruises of three or four weeks each to examine all the principal banks, and run lines of dredging and trawling and other observations across, around and between them, in order to ascertain the conditions that determine an oyster bed. Towards the end of the time I took part in the annual inspection of the pearl banks, by means of divers, along with the retiring inspector, Captain J. Donnan, C.M.G., and his successor, Captain Legge. During that period we lived and worked on the native barque *Rangasameeporawee*, and had daily opportunity of studying the methods of the native divers and the results they obtained. [These were discussed in the lecture and illustrated by lantern slides.]

It is evident that there are two distinct questions that may be raised—the first as to the abundance of the adult "oysters," and the second as to the number of pearls in the oysters—and it was the first of these rather than the frequency of the pearls that seemed to call for investigation, since the complaint has not been as to the number of pearls per adult oyster, but as to the complete disappearance of the shell-fish.

Most of the pearl oyster banks or "Paars" (meaning rock or any form of hard bottom, in distinction to "Manul," which indicates loose or soft sand) are in depths of from 5 to 10 fathoms, and occupy the wide shallow area of nearly 50 miles in length, and extending opposite Aripu to 20 miles in breadth, which lies to the south of Adam's Bridge. On the western edge of this area there is a steep declivity, the sea deepening within a few miles from under 10 to more than 100 fathoms; while out in the centre of the southern part of the Gulf of Manaar, to the west of the Chilaw Pearl Banks, depths of between one and two thousand fathoms are reached. On our two cruises in the *Lady Havelock* we made a careful examination of the ground in several places outside the banks to the westward, on the chance of finding beds of adult oysters from which possibly the spat deposited on the inshore banks might be derived. No such beds, outside the known "Paars," were found; nor are they likely to exist. The bottom deposits in the ocean abysses to the west of Ceylon are entirely different in nature and origin from the coarse terrigenous sand, often cemented into masses, and the various calcareous neritic deposits, such as corals and nullipores, found in the shallow water on the banks. The steepest part of the slope, from 10 or 20 fathoms down to about 100 fathoms or more, all along the western coast seems in most places to have a hard bottom covered with Alcyonaria, sponges, deep-sea corals and other large encrusting and dendritic organisms. Neither on this slope nor in the deep water beyond the cliff did we find any ground suitable for the pearl oyster to live upon.

Close to the top of the steep slope, about 20 miles from land, and in depths of from 8 to 10 fathoms is situated the largest of the "Paars," the celebrated Periya Paar, which has frequently figured in the inspectors' reports, has often given rise to hopes of great fisheries, and has as often caused deep disappointment to successive Government officials. The Periya Paar runs for about 11 nautical miles north and south, and varies from one to two miles in breadth, and this—for a paar—large extent of ground becomes periodically covered with young oysters, which, however, almost invariably disappear before the next inspection. This paar has been called by the natives the "mother-